## CLAIMS

What I claim is:

1. A purified nucleic acid segment comprising at least one of:

(A) a coding region encoding enzymatically active, soluble heparin synthase;

(B) a purified nucleic acid segment encoding an enzymatically active, soluble heparin synthase isolated from *Pasteurella multocida*;

(C) a purified nucleic acid segment encoding the soluble heparin synthase of SEQ ID NO:13 or 15;

(D) a purified nucleic acid segment encoding an enzymatically active, soluble heparin synthase, wherein the enzymatically active, soluble heparin synthase is at least 70% identical to SEQ ID NO:13 or 15;

(E) a purified nucleic acid segment comprising a nucleotide sequence in accordance with SEQ ID NO:12 or 14;

(F) a purified nucleic acid segment capable of hybridizing to the nucleotide sequence of SEQ ID NO:12 or 14 under low, medium or high stringency conditions;

(G) a purified nucleic acid segment having semiconservative or conservative amino acid changes or being a truncated segment when compared to the nucleotide sequence of SEQ ID NO:12 or 14;

(H) a purified nucleic acid segment having at least one nucleic acid segment sufficiently duplicative of the nucleic acid segment in accordance with SEQ ID NO:12 or 14 to allow possession of the biological property of encoding for a soluble *Pasteurella multocida* heparin synthase;

(I) a purified nucleic acid segment encoding an enzymatically active, soluble heparin synthase, wherein the enzymatically

active, soluble heparin synthase is a fragment of SEQ ID NO:2, 4, 6, 13, 15 or 34; and

(J) a purified nucleic acid segment comprising a fragment of a nucleic acid sequence in accordance with SEQ ID NO:1, 3, 5, 12, 14 or 33, and wherein the purified nucleic acid segment encodes an enzymatically active, soluble heparin synthase.

2. The purified nucleic acid segment of claim 1 wherein the purified nucleic acid segment is provided in a recombinant vector selected from the group consisting of a plasmid, cosmid, phage, integrated cassette or virus vector.

3. The purified nucleic acid segment of claim 2, wherein the recombinant vector containing the purified nucleic acid segment is used to electroporate, transform or transduce a host cell to produce a recombinant host cell having the recombinant vector.

4. The purified nucleic acid segment of claim 3, wherein the recombinant host cell produces heparin.

5. The purified nucleic acid segment of claim 3, wherein the recombinant host cell produces heparin synthase.

6. The purified nucleic acid segment of claim 3, wherein the enzymatically active heparin synthase is capable of producing a heparin polymer having a modified structure or modified size distribution.

7. The purified nucleic acid segment of claim 3 wherein the recombinant host cell further comprises at least one of an epimerase, a sulfotransferase, and combinations thereof.

8. A method for producing a heparin polymer *in vitro* comprising the steps of:

-- providing a soluble heparin synthase;

-- placing the soluble heparin synthase in a reaction mixture containing UDP-GlcNAc and UDP-GlcUA and at least one divalent metal ion suitable for the synthesis of a heparin polymer; and

-- extracting the heparin polymer out of the reaction mixture.

9. The method of claim 8 wherein, in the step of providing the soluble heparin synthase, the soluble heparin synthase is encoded by the purified nucleic acid segment of claim 1.

10. A purified nucleic acid segment comprising at least one of:

(A) a coding region encoding a modified heparin synthase, wherein the modified heparin synthase is capable of adding at least one of GlcUA and GlcNAc to a heparin polymer;

(B) a coding region encoding a modified soluble heparin synthase, wherein the modified soluble heparin synthase is capable of adding at least one of GlcUA and GlcNAc to a heparin polymer;

(C) a purified nucleic acid segment encoding a modified heparin synthase of SEQ ID NO:25 or 27 wherein the modified heparin synthase is capable of adding at least one of GlcUA and GlcNAc to a heparin polymer;

(D) a purified nucleic acid segment encoding a modified heparin synthase having at least about 70% identity to SEQ ID NO:25 or 27 and wherein the modified heparin synthase is capable of adding at least one of GlcUA and GlcNAc to a heparin polymer;

(E) a purified nucleic acid segment comprising a nucleotide sequence in accordance with SEQ ID NO:24 or 26;

(F) a purified nucleic acid segment capable of hybridizing to the nucleotide sequence of SEQ ID NO:24 or 26 under low, medium or high stringency conditions;

(G) a purified nucleic acid segment having semiconservative or conservative amino acid changes or being a truncated segment when compared to the nucleotide sequence of SEQ ID NO:24 or 26;

(H) a purified nucleic acid segment having at least one nucleic acid segment sufficiently duplicative of the nucleic acid segment in accordance with SEQ ID NO:24 or 26 to allow possession of the biological property of encoding for a single-action of *Pasteurella multocida* heparin synthase;

(I) a purified nucleic acid segment encoding a modified heparin synthase, wherein the modified heparin synthase is capable of adding at least one of GlcUA and GlcNAc to a heparin polymer, and wherein the modified heparin synthase is at least about 70% identical to SEQ ID NO:2, 4, 6, 13, 15 or 34; and

(J) a purified nucleic acid segment comprising a nucleic acid sequence at least about 70% identical to SEQ ID NO:1, 3, 5, 12, 14 or 33, and wherein the purified nucleic acid segment encodes a modified heparin synthase capable of adding at least one of GlcUA and GlcNAc to a heparin polymer.

11. The purified nucleic acid segment of claim 10 wherein the purified nucleic acid segment is provided in a recombinant vector selected from the group consisting of a plasmid, cosmid, phage, integrated cassette or virus vector.

12. The purified nucleic acid segment of claim 10 wherein the recombinant vector containing the purified nucleic acid segment is used to electroporate, transform or transduce a host cell to produce a recombinant host cell having the recombinant vector.

13. The purified nucleic acid segment of claim 10 wherein the recombinant host cell produces a modified heparin synthase is capable of adding at least one of GlcUA and GlcNAc to a heparin polymer.

14. A method for enzymatically producing a polymer, comprising the steps of:

-- providing a functional acceptor, wherein the functional acceptor has at least two sugar units selected from the group consisting of uronic acid and hexosamine;

-- providing a modified heparin/heparosan synthase capable of elongating the functional acceptor, wherein the modified heparin/heparosan synthase is a single action glycosyltransferase capable of adding only one of GlcUA or GlcNAc and has an amino acid sequence encoded by the nucleic acid segment of claim 10; and

-- providing at least one of UDP-GlcUA, UDP-GlcNAc and UDP-sugar analogs such that the modified heparin/heparosan synthase elongates the functional acceptor in a single step manner so as to provide a polymer.

15. The method of claim 14 wherein, in the step of providing a functional acceptor, uronic acid is further defined as a uronic acid selected from the group consisting of GlcUA, IdoUA, and GalUA.

16. The method of claim 14 wherein, in the step of providing the functional acceptor, hexosamine is further defined as a hexosamine selected from the group consisting of GlcNAc, GalNAc, GlcN and GalN.

17. The method of claim 14 wherein, in the step of providing the functional acceptor, the functional acceptor has about three sugar units.

18. The method of claim 14 wherein, in the step of providing the functional acceptor, the functional acceptor has about four sugar units.